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MINERALOGY OF THE ADIRONDACK FELDSPARS

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I. PLAGIOCLASE

1. OCCURRENCE. The principal constituent of the Adirondack anorthosites is plagioclase, and the associated gabbros, syenites, and intermediate rocks also contain plagioclase as an important

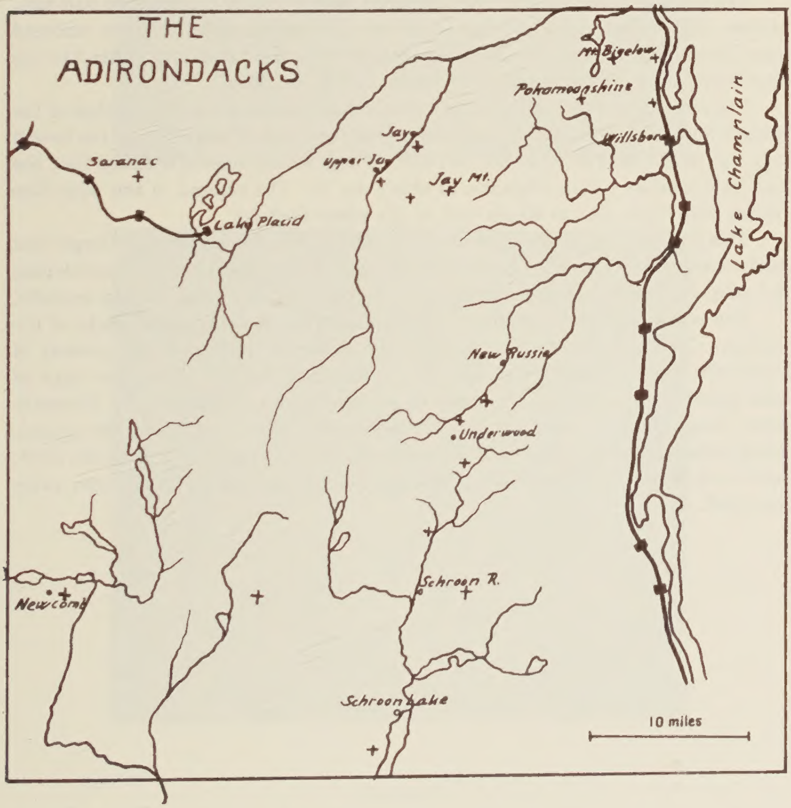


FIG. 1. Sketch map of the Adirondack Mountains. The small crosses indicate where material was collected.

Explanation to Plate I

Fig. 1. Inclusions in plagioclase. (The photograph is about 1/3 mm., across.)

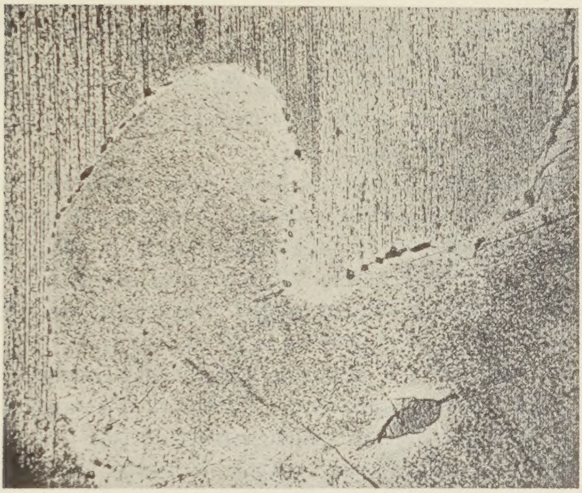
Fig. 2. Guttate perthite. (The photograph is about 1/3 mm., across.) The potash feldspar forms the groundmass and is the same as that occurring in the other perthites.

The plagioclase forms small drop-like spots, which usually are less than 0.02 mm. across. When these spots are studied under high magnification they are resolved into a multitude of very thin disc-like plates or films, one behind the other like the leaves in a book. These leaves are roughly parallel to (100).

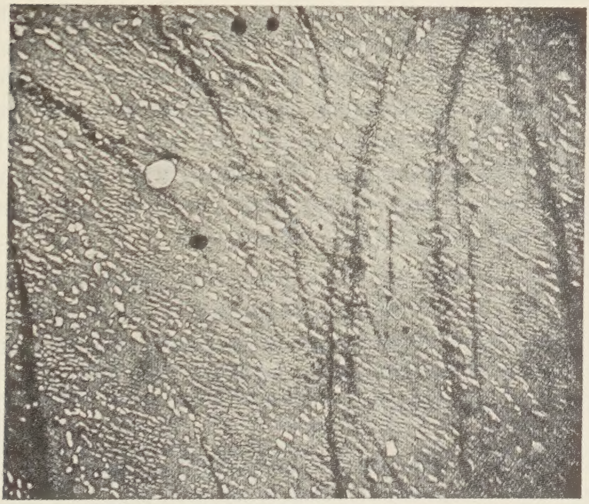
The indicatrix of the perthitic spots has almost the same position as that of the potash feldspar. On basal cleavage fragments the index of refraction of the fastest ray was determined to be $\alpha'(001) = 1.540$. These measurements indicate that the perthitic substance is an oligoclase of about An 23. The amount of this oligoclase varies from 0 per cent to 40 per cent of the whole feldspar.

This type can grade into a more vein-like type, the drops then grow larger and more compact, developing simultaneously a lens-like shape, often approaching 0.1 mm. in length, and thus displaying textural features similar to vein perthite.

The orientation of the perthitic sheets parallel to the contraction cracks of the feldspar (*cf.* O. Andersen, *l.c.*, p. 128), the great variability of the amount of oligoclase, and the passing into the vein perthite type, make it difficult to think of this perthite as formed by exsolution of a homogeneous mixed crystal. Probably these drops represent small nuclei of the oligoclase magma trapped by the crystallizing potash feldspar. The nuclei were thereby caused to assume a drop-like form, and were in a later stage partly squeezed out along contraction cracks (vein perthite).



1.



2.

PLATE 1.

mineral. A study of the plagioclase is, therefore, essential to a knowledge of the Adirondack rocks.

2. INCLUSIONS. The *oligoclase* is frequently associated with potash feldspar, thus forming different kinds of perthites and antiperthites and also twofold perthites, *e.g.*, plagioclase with antiperthitic inclusions of potash feldspar that in turn contains perthitic inclusions of plagioclase.

The *andesine* and *labradorite* form large, idiomorphic crystals with sharp and straight twin lamellae. They are always filled with inclusions of various kinds. A small amount of antiperthite and irregularly distributed grains of pyroxene, amphibole, ilmenite and probably spinel are always present. Occasional grains of pyrite, scapolite and garnet are regarded as secondary inclusions.

More conspicuous are, however, the dustlike particles of pyroxene that fill all these plagioclases. This dust is arranged in bands parallel to (010), occasionally also parallel to (001) of the plagioclase. At the contact of two crystals, however, the regularity is lost and the individual dust grains become much larger (see plate 1).

It is worth noting that such plagioclase crystals loaded with pyroxene will have a high density. Taking an actual case for example: It has been observed that in a sodic labradorite (density = 2.68) the amount of pyroxene inclusions is about 30 per cent. As the density of this pyroxene can not well be lower than 3.3, the density of the whole crystal is consequently 2.87. It ought not to be difficult for a crystal of that density to sink in a magma which is in equilibrium with a sodic labradorite.

3. OPTICAL PROPERTIES. There has been much discussion as to whether or not the Adirondack plagioclase contains potash in solid solution. In this section facts will be presented that prove the non-existence of an admixture in solid solution of potash feldspar (as well as of carnegieite).[1]

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[1] Chemical studies of these feldspars are rendered difficult by the presence of perthites and other intergrowths that make it impossible to get pure material for an analysis.

Through a combination of chemical and geometrical analyses of plagioclases of the St. Urbain anothosites Mawdsley was able, however, to demonstrate the non-presence of potash in the molecules of these plagioclases. This statement finds confirmation in the present optical measurements. (F. B. Mawdsley, St. Urbain Area, Charlevoix District, Quebec. *Canada Geol. Surv. Mem.*, **152,** 1927.)

With the Fedorow universal stage it is possible to determine the value of the axial angle and the position of the indicatrix of a plagioclase.

In Fig. 2 the results of the measurements of 15 different, well developed crystals from various parts of the Adirondacks are plotted and compared with the position of the indicatrix of the "normal" plagioclase. All the measurements agree with the curves for the normal plagioclase within the limits of error. It is highly improbable that an appreciable amount of either the potash feldspar or carnegieite would not cause an observable alteration

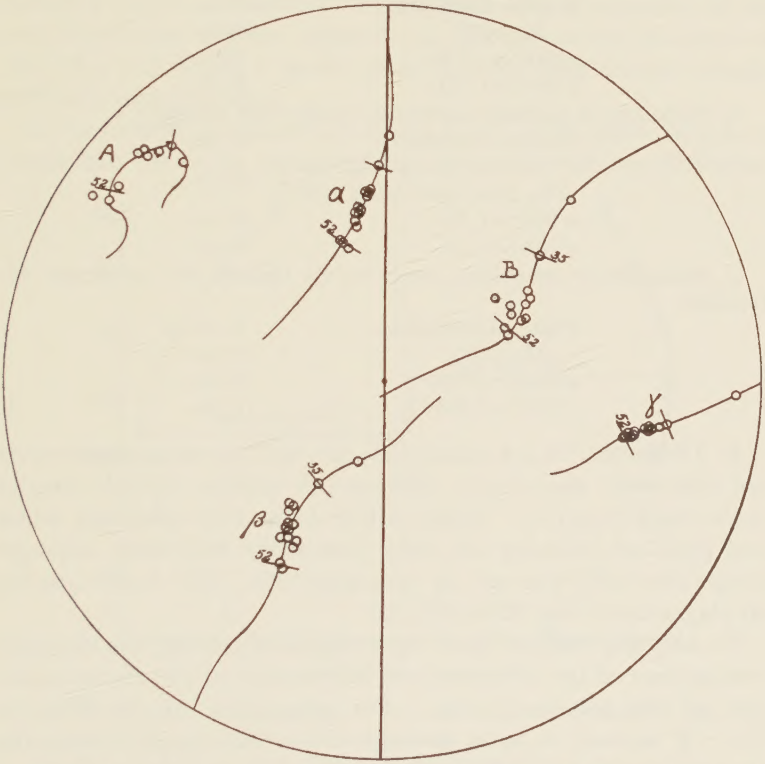

Fig. 2. Stereographic projection of the optical elements of different plagioclases on a plane ⊥ to *c* axis. The measurements are plotted as small circles. The curves indicate the positions of the optical elements in the normal plagioclase series (according to Duparc and Reinhard). The positions of plagioclases consisting of 35 and 52% An are especially indicated. It is seen that most of the Adirondack plagioclases contain from 40 to 50% An.

of the shape of the indicatrix, and throw it far out of its normal position.

The following measurements show how the different optical determinations check each other.[2]

1. Phenocrysts in syenite, Aiden Lair (Newcomb).
   Position of indicatrix: 51 An
   $2V_\gamma = 79°$: 48 An
   $\alpha'(001) = 1.554$: 50 An
   $\gamma'(001) = 1.561$: 51 An
2. Phenocrysts in gabbroid anorthosite, Moody Pond (Saranac).
   Position of indicatrix: 46 An
   $2V_\gamma$, red light $(670\mu\mu) = 86°$ } 42 An
   $2V_\gamma$, green light $(510\mu\mu) = 85°$ }
   $\alpha'(001) = 1.557$: 54 An
   $\gamma'(001) = 1.563$: 54 An
3. Phenocrysts in anorthosite, quarry on the highway N.E. of Shingle Bay (Saranac).
   Position of indicatrix: 51 An
   $2V_\gamma = 77°$: 50 An
   $\alpha'(001) = 1.555$: 51 An
   $\gamma'(001) = 1.561$: 51 An

4. TWINNING. It is a remarkable fact that the large phenocrysts are frequently untwinned, whereas the smaller crystals usually show much twinning. Simple albite twins and combined albite and pericline twinning are most commonly met with, although simple pericline twins are by no means rare. This holds true for all plagioclases from 20 to 60% An.

No accurate relation could be established between the chemical composition of the feldspars and the position of the rhombic section of the pericline twins. For plagioclase of 40–50% An $\mathfrak{S} = -4°$ seemed to be an average value. ($\mathfrak{S}$ = angle between the rhombic section and the base.) But not infrequently the value of $\mathfrak{S}$ was found to be zero; in fact, various feldspars in the range from 20 An to 55% An exhibited pericline twins with $\mathfrak{S} = 0°$. Probably these twins ought to be regarded as Aclin A-twins.

It is worth recording that a small plagioclase crystal of 50% An (in anorthosite from Shingle Bay), in addition to pericline twinning also showed the very rare complex twin of the albite-Ala B type. But except for this case, only albite and pericline twins have been observed.

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[2] The determination of the position of the indicatrix and of the axial angle were made with a Fedorow stage. The determination of the refraction on basal cleavage pieces was made by the immersion method, (the tables of Tsuboi were used for interpretation).

It should also be mentioned that not infrequently only an approximate realization of the twin laws has taken place.

Such a case may be rather accurately established with the Fedorow stage. If, namely, the principal optical elements of one twin individual are not symmetrical relative to the elements of the other individual, it would mean that the twin did not comply perfectly with the law.

If the crystal is twinned according to the albite law a very good check can be made by mounting the twin with its (010)-face vertically, adjusting the trace of (010) parallel to or symmetrical with the directions of the nicols, and rotating about the axis ⊥ to (010). During this rotation the ideal twin will exhibit an equal illumination, whereas an incomplete adjustment of the individuals in twin position will cause marked differences in the illumination. A deviation of less than one degree is easily observed in this way. The actual amount of deviation is, however, most accurately found by measuring the difference between the positive of maximum extinction between the two individuals in the zone ⊥ to (010).

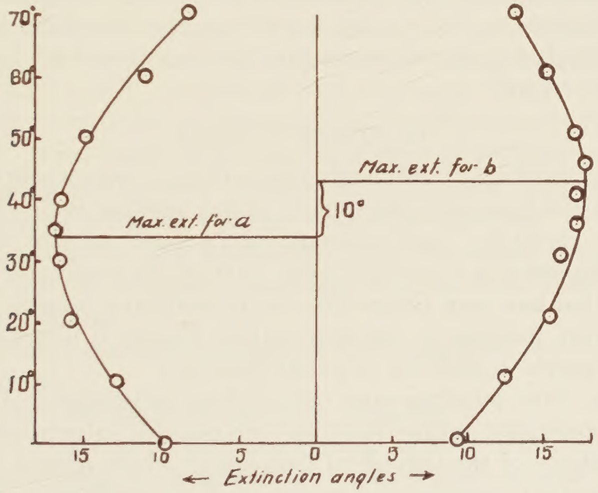

FIG. 3. Graphical representation of the extinction phenomena in the zone ⊥ to (010) of the andesine twin from Split Rock Falls.

Abscissa: extinction angles of the two individuals.

Ordinate: directions in the plane of (010) (twinning plane).

Quoting an actual example, afforded by an andesine of the anorthosite of Split Rock Fall will make this procedure clear.

The twin concerned consists of two individuals, *a* and *b*, polysynthetically twinned according to the albite law.

Determinations with the Fedorow stage show a relative displacement of 10° of the optical elements of each individual; the twin does not display an equal illumination in the positions just described; and the difference between the positions of maximum extinction for the two individuals in the zone $\perp$ to (010) is 10°. (See Fig. 3).

In this case the same thing has thus been indicated by so many single observations that there can be no doubt about the twin individuals having their *c*-axes, *ca.* 10° apart in the plane of (010). The revolution about the twin axis has thus been 190° (or 170°) instead of 180°.

II. POTASH FELDSPAR

1. Occurrence. Although the principal constituent of the anorthosites is a calcic plagioclase, potash feldspar is also present, both interstitially, and accumulated in small pegmatitic nests which represent a somewhat larger part of the magmatic mother liquor that has been trapped by the crystallizing magma. These nests, very irregular in size and outline, consist of *oligoclase*[3] and a little *quartz* in addition to *potash feldspar*.[4]

These three minerals may be found as individual grains, and also as perthitic, antiperthitic, and myrmekitic intergrowths, the compositions of the individual minerals of which remain remarkably constant regardless of texture and proportions of the constituents.

Consequently it should be emphasized that only two individual feldspars occur in these pegmatitic nests, *viz.*, a comparatively pure potash feldspar and a pure oligoclase of about 23% An.

2. Perthitic intergrowths. Various types of association of feldspars have been studied and classified by Olaf Andersen.[5] He has developed what he calls "a tentative scheme of classification, based on textural features only." As he has shown, however, the textural features undoubtedly indicate the mode of formation

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[3] An_{23}; $2V_\gamma = 84°$.

[4] Both triclinic and apparently monoclinic; $a{:}\alpha' = 7°$ in (010); $2V_\alpha = 67-76°$.

[5] Olaf Andersen, Genesis of Feldspar from Granite Pegmatites: *Norsk. Geol. Tidsskr.*, **10**, 116, 1928.

of the perthites, and his classification thus becomes genetical as well as physiographical. In order to save space reference is hereby given to his descriptions and illustrations, and the names introduced by him will be adopted without further explanations.

The perthites of the Adirondack rocks belong to the following types:

1. Guttate perthite, very common.
2. Vein perthite, not characteristically developed.
3. Patch perthite, not rare.
4. Interlocking perthite, common.

The guttate perthite has not been described by Andersen. The name is, therefore, introduced for a new textural type, essentially different from all the nine types contained in Andersen's classification. A description of it is given as text to plate 1. The other types are directly comparable with those described by Andersen.

Every proportion of potash feldspar to oligoclase has been observed. If one begins with a potash feldspar of 100 per cent purity, one can go continuously through the guttate perthites, patch- and interlocking perthites, ending with a pure oligoclase.

3. GENESIS OF THE PERTHITES. The Adirondack perthites are either due to secondary unmixing, simultaneous crystallization, or replacement.

The following facts are supposed to be against the theory of an unmixing.

1. The basicity of the perthitic substance.

2. The fact that the interlocking perthite—which has been formed through a simultaneous crystallization of both feldspars (*cf.* O. Andersen, loc. cit. p. 181)—grades into the other types.

3. The fact that all the plagioclases in the pegmatitic nests are of the same composition (which indicates that they all have been deposited from the same liquid, at about the same time).

4. The great variability in the proportions of the individual phases of the perthites.

In the writer's opinion these perthites have been formed simultaneously with the other minerals of the pegmatites; they have all been precipitated from a liquid with which both potash feldspar and plagioclase were in equilibrium, generally speaking. They have separated out in part as larger homogeneous crystals of microcline and oligoclase, in part as a rhythmical crystallization (interlocking perthite!) and the crystallizing potash feldspar in some instances has hemmed in tiny drops of oligoclase (guttate perthite!).

In the concluding stages some mutual replacement has taken place (patch- and vein perthites!).

SOME CONCLUSIONS

In the anorthosites of the Adirondacks two clearly separated stages of crystallization can be distinguished.

During the first stage a potash-free, homogeneous andesine-labradorite was formed, and as no zoning occurs it must be assumed that the labradorite during a very long period had been in equilibrium with a magma (mother liquor) consisting essentially of (molten) oligoclase and potash feldspar.

During the second stage the mother liquor froze, forming potash-free oligoclase and comparatively pure potash feldspar.

The pure labradorite melts somewhat below 1300°, and the perthitic potash feldspar at about 1000°.

The temperature of crystallization of the feldspathic magma is, however, difficult to state, as that would vary with the amount of mineralizers present.

If it be assumed that the anorthositic mother liquor was poorer in mineralizers than the magma of an ordinary granite, it would mean that the potash feldspar formed at, or somewhat above 700°,[6] would be unable to take up any considerable amount of oligoclase in solid solution, and *vice versa.*[7]

4. OPTICAL PROPERTIES OF THE POTASH FELDSPAR. The potash feldspars associated with the Adirondack anorthosites may, according to common practice, be classified in part as orthoclase, and in part as microcline, the difference being that microcline shows an inclined extinction, whereas orthoclase, being a monoclinic mineral, is supposed to show parallel extinction in the zone normal to (010). As a matter of fact most of the so called orthoclase from different types of rocks does not display perfect parallel extinction. According to my experience, the deviation, though small, usually varies from 1° to 3°.

Such is also the case with the potash feldspars from the Adirondacks. Some of them do have parallel extinction, but usually small deviations may be observed, and even on one and the same crystal different areas will exhibit different values for the extinction angle; indeed, within one crystal consisting principally of orthoclase, even the "quadrille" structure so characteristic of microcline may be observed here and there. The extinction angle on the base may have any value between zero and fifteen degrees. If, however, the extinction angle exceeds 4°–5°, usually the "cross-hatching," due to the microscopic lamellar twinning of the microcline, will appear. The axial angle of the orthoclase is about 70°, that of the microcline is usually slightly larger.

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[6] E. S. Larsen, The Temperature of Magmas: *Am. Mineralogist,* **14,** 81, 1929.

[7] The crystallization of the potash-free andesine has obviously taken place at an appreciably higher temperature.

From these properties it is, however, difficult to state whether the potash feldspar is pure, or whether it is an anothoclase, carrying the soda feldspar in solid solution.

A determination of the indices of refraction for different wavelengths was therefore undertaken in order to determine whether the feldspar was anorthoclase. The principles of this improved method for studying powdered minerals have been given by Merwin, and later by Tsuboi, and others, and it is claimed, if care is exercised, the experimental error may be reduced to about two units in the fourth decimal place.

Large crystals of perthitic potash feldspars from a pegmatitic nest in the anorthosite of the south-eastern slope of Pokamoonshine Mt. were used. The crystals may be said to consist mainly of orthoclase, although the extinction angle on (001) is rarely zero, usually varying from 1°–3°. Also here and there the "quadrille" structure of microcline appears, and at such places the extinction angle on the base will vary from 4° to 15°.

For the orthoclase the values shown in table 1 were obtained.

TABLE 1.

	$486\mu\mu$	Na-light	$656\mu\mu$
n_p	1.5278	1.5230	1.5198
n_m		1.5270	
n_g	1.5338	1.5288	1.5255

For sodium light, $n_g - n_p = .0058$; $n_m - n_p = .0040$; $n_g - n_m = .0018$.
The dispersion of n_p, $F-C = .0080$; that of n_g, $F-C = .0083$.
The axial angle, $2V_\alpha = 68°$, no visible dispersion.

A microcline of the same crystal shows the following properties: Extinction angle on (001) is $=15°$, the axial angle $2V_\alpha = 75°$. The refractive indices for sodium light are:

$$n_p = 1.5225$$
$$n_m = 1.5268$$
$$n_g = 1.5293.$$

As essentially the same data are given for other potash feldspars it may be concluded that the investigated feldspars are comparatively pure species. It is, however, worth noticing that there do occur potash feldspars, especially orthoclases, with considerably lower indices of refraction, and although our feldspar is far from being anorthoclase it, nevertheless, may contain small amounts of albite in solid solution.

5. THE TWINS. Usually these potash feldspars are untwinned, and megascopically visible twins were in no case observed. A microscopic lamellar twinning of extreme thinness may, however, often be seen.

It is especially noteworthy that simple twinning acording to the albite law has been observed, the extinction angle on the base of these twins is very small, only about 1°, it must be assumed that the orthoclase variety of the potash feldspar in exhibiting this type of twinning, indicates that it is really triclinic with a very close approach to the monoclinic symmetry rather than truly monoclinic.

A simple twinning of the triclinic potash feldspar is very uncommon. Miss Reynolds[8] has, however, observed a very similar lamellar twinning on (001) in the case of authigenic potash feldspar of the Leicestershire marl, and a triclinic adularia exhibiting simple twinning of the acline B-law, and Carlsbad twins of simple microcline are also on record.[9] But these cases furnish probably the only known examples of simple twinning of triclinic potash feldspars.

In all other cases the multiple-twinning causing the well known "cross-hatching" has been observed. It is hard to understand why the microcline, if twinned, always shows two sets of lamellar twinning, but it is a fact that also holds true for the Adirondack feldspars.

The microcline of this area looks however, a little different from ordinary microcline as the twinning bands are usually very narrow and short. The twins are visible only with a high-powered objective, and many areas which with a medium magnification seem homogeneous, are resolved into numerous small twins when a higher magnification is used; one can hardly get rid of the impression that if it were possible to use still higher magnifications other areas of the orthoclase would reveal tiny (submicroscopic) twins. It would therefore be interesting to calculate the properties of a mineral which would be formed if the Adirondack microclines were really made up of submicroscopic twins.

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[8] D. L. Reynolds, *Geol. Mag.*, **66**, 390, 1929.

[9] T. Barth, *Zeitschr. f. Krist.*, **68**, 473, 1928; *Chemie der Erde*, **4**, 119, 1928.

6. THE EFFECT OF SUBMICROSCOPIC TWINNING. The optical phenomena produced by the superposition of small crystalline lamellae have been mathematically discussed by Mallard.[10]

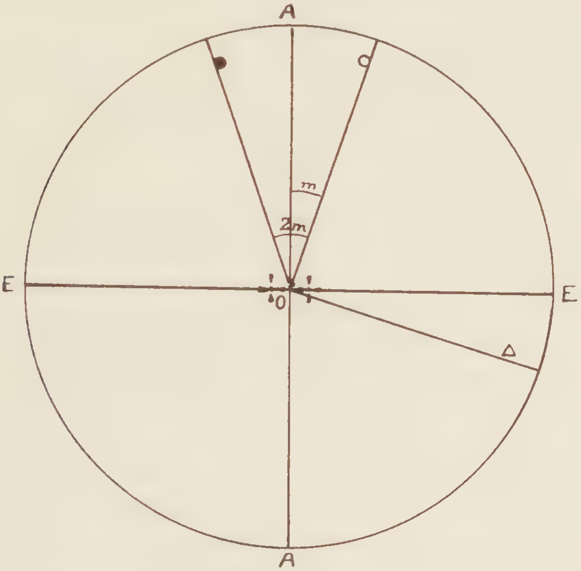

FIG. 4. Stereographic projection of the optical elements of a microcline twin on a plane symmetrical with the β-directions. $\text{o}=\alpha$, $+=\beta$, $\Delta=\gamma$, $A-A$ = twinning plane.

It can be shown that the optical properties of a packet of small crystalline lamellae can be always represented by Fresnel's ellipsoid, the shape and dimensions of which are independent of the order in which the lamellae is packed, depending only on the nature and the relative proportion and orientation of each lamella.

In a submicroscopically twinned microcline the twins presumably belong to the albite and pericline types. In the former the axis ⊥ to (010), in the latter the b axis, is the twin axis. As these two directions are only a few minutes of arc apart,[11] in the following calculations they will be regarded as coinciding.

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[10] E. Mallard, *Bull. Soc. Min. France*, **4**, 71, 1881; *Traité de cristallographie*, II, Paris, **1884**, p. 263.

If one constructs the indicatrix ellipsoid of every one of the small twins, giving each of them a value of ϵ/E (ϵ = the thickness of the twin, E that of the whole packet), and along each direction draw a line equal to the sum of the radius-vectors corresponding to the direction, a certain surface is obtained, which can be shown to be the indicatrix ellipsoid of the whole packet. For the purpose of finding the properties of the resulting ellipsoid it is expedient to consider the propagation of light along a direction corresponding to the b axis of orthoclase.

Fig. 4 is a stereographic projection of the optical elements of the described microcline twin on a plane normal to said direction. The extinction angle of the microcline in this plane is

$$m = 17°,$$

referred to the trace of the twinning plane. Such a twin corresponds thus to a packet of two identical lamellae crossed at an angle equal to $2m$. The faster of the two rays propagating through the microcline along this direction has an index of refraction n_p', almost equal to n_p of the microcline = 1.5225. The slower ray has an index of refraction n_g', that is slightly lower than n_g of the microcline. Calculations show that $n_g' = 1.5292$.

The two indicatrices corresponding to the positions of the two twin individuals are identical and are symetrically placed with reference to the twinning plane (the bisector of the angle $2m$). The resulting indicatrix that determines the optical properties of the packet admits thus the twinning plane and a plane normal to this, E-E, as symmetry planes, see Fig. 4. Or the axes of the resulting indicatrix will lie at A, E, and O of Fig. 4.

This result was arrived at by Mallard[12] and Michel-Lévy[13] 50 years ago. But we may now also determine the lengths of the axes of the ellipsoid.

If N_p and N_g indicate the values of the resulting refractive indices corresponding to the axes at A and E, respectively, it can be shown that approximately:

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[11] T. Barth, *Fortschritte der Mineralogie*, etc., **13**, 31, 1929.

[12] E. Mallard, *loc. cit.*

[13] A. Michel-Lévy, *Bull. Soc. Min. France*, **2**, 135, 1879.

$$N_p = \frac{n_p' + n_g'}{2} - \frac{n_p' - n_g'}{2} \cdot \cos 2m,$$

$$N_g = \frac{n_p' + n_g'}{2} + \frac{n_p' - n_g'}{2} \cdot \cos 2m.$$

The value of the third axis N_m may be found in the same way by considering the propagation of light along a direction corresponding to the *a* axis of orthoclase.

Table 2 contains the calculated values compared with the observed values for the Adirondack orthoclase.

TABLE 2.

Calculated	Observed	Diff.
$N_p = 1.5231$	1.5230	−.0001
$N_m = 1.5269$	1.5270	+.0001
$N_g = 1.5286$	1.5288	+.0002
$2V_\alpha = 67.5°$	68°	+.5°

This table shows clearly that the differences fall within the limits of error and that the observed optical properties of the Adirondack orthoclase are readily explained as a result of twinning of submicroscopically small microcline individuals.

The small deviation from parallel extinction in most of the orthoclases can easily be explained through the assumption that one of the twin systems predominates, a condition which, of course, frequently exists; also the variation of the axial angle is a necessary consequence of this phenomenon.

ACKNOWLEDGMENTS

The field work connected with this research was made possible by subsidies received from the Department of Mineralogy and Petrography of Harvard University.

The laboratory work was mostly done in the same Department during the tenure of a Fellowship of the International Education Board.

The writer wishes to express his hearty thanks to professors E. S. Larsen and Charles Palache, for their kind interest in the work and the excellent facilities offered both in the field and in the laboratory.

KAOLINITE FROM A BROOKLYN SUBWAY TUNNEL*

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INTRODUCTION

A white clay forming small patches in deeply weathered rock is occasionally encountered in excavations east of the Harlem River and East River in New York City. Specimens of this material were recently examined and the white clay mineral identified as kaolinite, as strictly defined. The white clay furnishes evidence of interest concerning the origin of the mineral kaolinite, and adds another locality to the rather meagre list of those in which kaolinite has been recognized by modern methods.

ACKNOWLEDGMENTS

The writer wishes to express his appreciation of the efforts of Mr. E. A. Kilinski, consulting geologist for the subway excavation, who collected specimens of the white clay and associated rock as the work advanced. It was also through Mr. Kilinski's efforts that an opportunity was offered to visit the locality during the progress of the work. Professor R. J. Colony of Columbia University has shown special interest in the study of the specimens and has offered numerous observations of value. The present account is an outgrowth of work on clay minerals carried on for the last few years in cooperation with Dr. Clarence S. Ross of the United States Geological Survey to whom the writer is greatly indebted for his generous suggestions. The portions of this description dealing with nomenclature are summarized from a joint paper in which Dr. Ross is the senior author, to be published shortly by the United States Geological Survey.

THE SIGNIFICANCE OF KAOLINITE

The word *kaolinite* as herein employed is intended to signify common kaolin of the type found throughout the southeastern part of the United States and in numerous other places. Kaolinite has been subject to two different interpretations in mineralogical literature. A brief explanation is justified, therefore, in order to clarify the meaning of the word as used in this paper. Two different minerals have been rather consistently called kaolinite. These may be designated as: (1) A clay mineral from the Isle of Angelesey investigated by Dick;[1] (2), A clay mineral of the type studied by Johnson and Blake.[2] Recent work[3] has demonstrated that these are two independent clay minerals differing in crystallization, physical properties and temperature of dehydration but having the same chemical composition. It has been suggested that the clay mineral from Angelesey be called *dickite* in recognition of the optical work of Allan Dick[4] who so ably recorded the properties of the mineral in 1888. The name kaolinite, it has been considered, should be retained for common kaolin which represents the type studied by Johnson and Blake.

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* Paper read at the tenth annual meeting of the Mineralogical Society of America, Washington, D. C., December 27, 1929.

TABLE 1.

KAOLIN MINERALS

NAME	CHEMICAL COMPOSITION	X-RAY DIFFRACTION PATTERN	OPTICAL PROPERTIES
NACRITE	$Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$	Distinctive	Distinctive from other minerals but nearly the same for dickite and nacrite.
DICKITE	$Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$	Distinctive	
KAOLINITE	$Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$	Distinctive from other minerals but identical for kaolinite and anauxite.	Distinctive from other minerals but nearly the same for kaolinite and anauxite.
ANAUXITE	$Al_2O_3 \cdot 3SiO_2 \cdot 2H_2O$		

(*After Ross and Kerr*)

In addition to *kaolinite* and *dickite*, two other minerals occur in the kaolin group, which show certain physical or chemical properties indicating relationship to *kaolinite* and *dickite*. These should be kept in mind in any discussion dealing with the identification of kaolin. The other two minerals are *nacrite* and

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[1] Tookey and Dick, *Percy's Metallurgy Fuel*, 1875, and *Min. Mag.*, **8**, 15, 1888.

[2] Johnson, S. W., and Blake, J. M. On Kaolinite and pholerite: *Am. Jour. Sci.*, 2nd Ser., Vol. **43**, pp. 351–361, 1867.

[3] Ross, Clarence S., and Kerr, Paul F. The Minerals of Kaolin, (in press).

[4] Ross, Clarence S., and Kerr, Paul F. Dickite a kaolin mineral: *Amer. Min.*, Vol. **15**, No. 1, pp. 34–39, 1930.

anauxite. Nacrite agrees in chemical composition with ***kaolinite*** and *dickite* but differs in crystallization (as shown by x-ray diffraction patterns). In addition it has somewhat different optical properties. Anauxite is probably isomorphous with kaolinite. It has nearly the same optical properties, and gives the same x-ray diffraction pattern as kaolinite, but contains materially different amounts of alumina and silica in the chemical formula. The relationship between these four minerals is summarized in table 1.

It will be noted in examining table 1 that no one method of identification, such as chemical analysis, x-ray study, or optical examination is sufficient in all instances to distinguish these minerals from each other. On account of this situation, the identification of a kaolin should be approached with caution and should not be considered complete until at least two and preferably more methods of study have been exhausted.

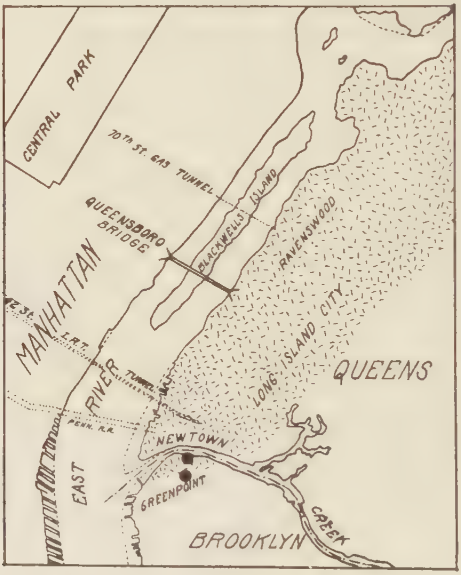

FIG. 1. Sketch map of Newtown Creek and vicinity showing the kaolinite localities and the approximate boundaries of the Ravenswood granodiorite.

LOCATION

The specimens examined were collected in the new city subway tunnel in the vicinity of Newtown Creek, along the boundary between the boroughs of Brooklyn and Queens (See Fig. 1). The new subway line consists at this point of two parallel tunnels extending north-south and excavated to a level below the bottom of Newtown Creek. The principal white clay localities occur in the west tunnel 50 and 550 feet, respectively, south of the U. S. Government bulkhead line of Newtown Creek. No exposures of rock are visible at the surface. The localities lie beneath buildings and alongside of the south approach to the vehicular bridge over the Creek at Vernon Avenue. All of the specimens examined were collected in the fall of 1928 and early in 1929. The tunnel has since been lined with concrete and new material is no longer available at this point.[5]

The Local Geology

Much has been written on the geology of Greater New York.[6] In these accounts both the surface geology and the areal distribution of the formations underlying the glacial drift have been mapped in considerable detail. The portion of Long Island in the vicinity of Newtown Creek is generally considered to be underlain by the Ravenswood granodiorite. The most recent and accurate records of the geology of this portion of the city are contained in discussions by Professor Berkey. In describing the formational units underlying the city, he states:

"Another is known to be of large areal extent in Long Island City and Brooklyn, extending beneath the East River into the Lower East Side of Manhattan. It is known to recent workers in the geology of New York City as the Ravenswood granodiorite. It is probably the most ancient igneous or strictly intrusive rock in New York City and is associated only with the Fordham Gneiss the oldest of all the formations in southeastern New York."[7]

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[5] Since the above was written, Prof. W. M. Agar of Columbia University has observed another deposit of kaolinite about a mile south of Newtown Creek in a more recently excavated continuation of the same tunnel.

[6] See for instance: *Folio No.* **83**, *U. S. Geological Survey.* Hobbs, W. H., The Configuration of the Rock Floor of Greater New York: *Bull.* **270**, *U. S. Geological Survey.* Berkey, C. P., *Areal and structural geology of Southern Manhattan Island*: (Part 2, pp. 247–282, Apr. **1910**); The Geology of New York City: *Proc. Municipal Engineers of the city of New York*, **1911**, pp. 5–39; Geology of the New York City (Catskill) Aqueduct: *New York State Museum Bull.* **146**, Feb. 1911.

[7] Berkey, C. P., The Geology of New York City, *op. cit.*

The name Ravenswood granodiorite was first suggested by Professor Kemp,[8] who in writing a detailed description of a section across East River at Blackwells Island, along a gas company's tunnel stated:

"There is good reason to think the Ravenswood rock an intrusive hornblende-granite or granite-diorite, with which it agrees in mineralogical composition."

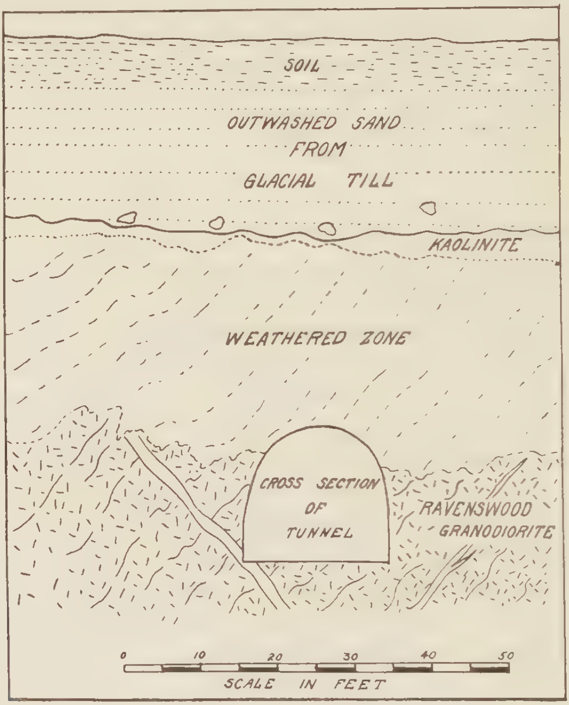

FIG. 2. Generalized section of the weathered and kaolinized Ravenswood granodiorite as it occurs beneath the glacial till.

Ziegler prepared a petrographic description of the Ravenswood granodiorite and mapped the areal extent of the intrusive under Professor Berkey's direction.[9] The distribution of the granodiorite shown in Figure 1 has been compiled from his report and from information furnished by Mr. E. A. Kilinski.

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[8] Kemp, James F., The Geological Section of the East River at 70th St. New York: *Trans. N. Y. Acad. Sci.*, Vol. **14**, p. 273.

[9] Ziegler, Victor, The Ravenswood granodiorite: *Ann. N. Y. Acad. Sci.*, Vol. **XXI**, pp. 1–10.

Occurrence of White Clays in Greater New York

It is only during tunneling or deep excavating operations that one is provided with an opportunity to examine the rock underlying the glacial drift in this area and to study types of alteration. The clay at Newtown Creek occurs in patches in a weathered zone below the contact between the underlying Ravenswood granodiorite, and overlying outwashed sand from glacial drift. The weathered zone varies from 15 to 35 feet in thickness where cut by the tunnel and is made up of the decayed granodiorite. The top of this zone is irregularly capped with a layer of white clay varying from a few inches to two feet in thickness. North of Newtown Creek in Long Island City other zones of decayed rock occur, but white clay was not encountered in cutting the tunnel.

White clays, probably of this type, have previously been reported by Humphreys and Julien[10] and also by Professor Kemp.[11] It appears from these previous descriptions and from field observations at this locality that the kaolinized areas are residual portions of a pre-glacial weathered surface not swept away by the glacier. Humphreys and Julien emphasized this pre-glacial age of the kaolinization. They reproduced a photograph of a nearly vertical kaolinized pegmatite dike, planed off by glaciation and overlain by glacial drift. An accompanying decay in the adjacent rock was reported, which from their description, corresponds to weathered zones along the subway tunnel.

The kaolin on Long Island is limited to the surface or near surface portions of the rock, and is not encountered in the deep tunneling operations beneath the city.[12] The alteration is apparently not restricted to one particular phase of the granodiorite, but extends laterally across both the granodiorite and the pegmatites by which it is cut. The distribution of the areas is erratic and seemingly without relation to the present topography. Portions of the underlying rock in which one would expect recent weathering action to be most active are often least altered.

Professor Kemp[13] encountered a number of kaolinized zones in the gas tunnel section beneath the East River at Blackwells Island. A portion of his description at a point 430 feet from the west shaft along the waterfront at the foot of E. 70th Street reads as follows:

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[10] Humphreys, Edwin W., and Julien, Alexis A., Local decomposition of rock by the corrosive action of pre-glacial peat-bogs: *Jour. Geol.*, Vol. **19**, No. 1, Jan.–Feb. 1911, pp. 47–56.

[11] Kemp, J. D., *op. cit.*

[12] Berkey, C. P., Statement in conversation.

[13] *Op. cit.*

" 7 ft.	white kaolinized pegmatite.
5 ft.	soft black mud with lumps of lignite, with the next seven feet evidently filling a fissure.
2 ft.	coarse river sand with abundant pyrites.
5 ft.	sand and black mud with lignite and balls of pyrites.
22 ft.	white kaolinized pegmatite with lumps of foetid quartz.
4 ft.	same, streaked with chlorite.
11 ft.	kaolinized pegmatite.
42 ft.	soft green chlorite schist."
Total 98 ft.	

Samples of both white clay and the green chlorite (probably vermiculite) were examined by Professor Kemp who attributed the white clay to kaolinization of the pegmatite, and the green chlorite to decomposition of mica schist. Humphreys and Julien attribute the formation of the white clay and the deep local decay of the rock to the continuous corrosion of ancient pre-glacial peat-bogs. They mentioned the occurrence of remnants of such peat-bogs in a number of places throughout the area covered by Greater New York. The presence of bog-iron in some of these, they believe, indicates the early and long continued activity of organic acids in solution, removing, concentrating and depositing iron oxide from the surface of the rocks.

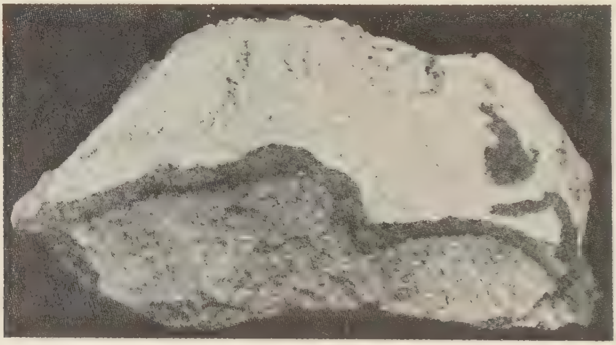

FIG. 3. (1/2 natural size.) Successive stages in the kaolinization of the granodiorite as exhibited in a hand specimen. The rock is evidently first decayed as shown in the lower half; then a limonitic band advances and the kaolinite and quartz shown in the upper half is the final product.

The occurrence of the kaolin in the decayed Ravenswood granodiorite is probably similar to that discussed by the authors mentioned above. It does not, however, appear to be limited to the alteration of pegmatites, as might be inferred from the East River occurrence, but corresponds more nearly to the occurrence at the intersection of Westchester Avenue and Southern Boulevard in the Bronx, described by Humphreys and Julien. Figure 2 illustrates the occurrence along the subway tunnel as interpreted from tunneling operations and drill holes.

The progress of the alteration can be observed in hand specimens as shown in Figure 3. A limonitic band separates the kaolinite from partially decayed granodiorite.

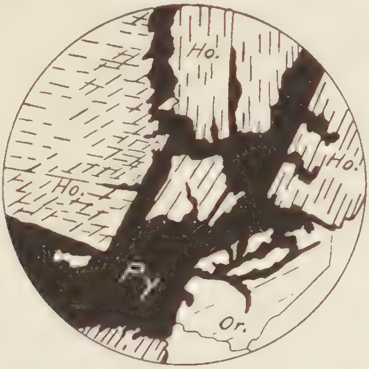

Fig. 4. Drawing of thin section×25. Hornblende (Ho), Orthoclase (Or), and Pyrite (Py) are the minerals present. A portion of the granodiorite containing a concentration of pyrite probably "magmatic" but later than the silicate minerals.

THE CHARACTER OF THE RAVENSWOOD GRANODIORITE

The texture of the rock is extremely varied, fine grained portions changing abruptly to coarsely crystallized patches having individual crystals an inch or more across. Irregular foliation and streaks of injected matter are prominent. The rock is traversed by numerous dikes which are unaltered below the zone of rock weathering.

Orthoclase, quartz, oligoclase, hornblende, and biotite are the most abundant minerals in the granodiorite. Microcline, apatite, zircon, garnet, titanite, and muscovite are scattered through the rock in minor amounts. Pyrite is frequently observed in more or less minor concentrated areas as a late magmatic product (Fig. 4). Some sericite may be seen in the pegmatitic phases or in areas containing concentrations of feldspar. The minerals noted in the fresh and unaltered granodiorite are practically the same as those recorded by Ziegler.[14] Ziegler, however, evidently failed to encounter any considerable area of rock weathering or in any event did not discuss such a feature. He mentioned the introduction of carbonates, and included kaolin in his mineral list but did not go farther in his explanation.

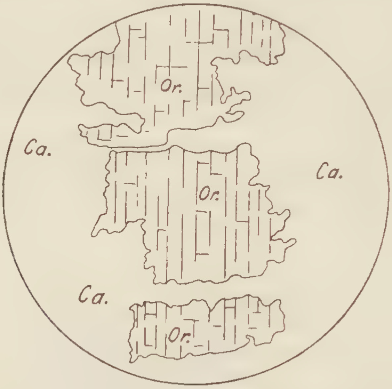

FIG. 5. Drawing of thin section×25. Orthoclase (Or) "etched out" and in part replaced. The filling in each instance consists of calcite (Ca). An alteration noted in both unkaolinized and partly kaolinized portions of the granodiorite.

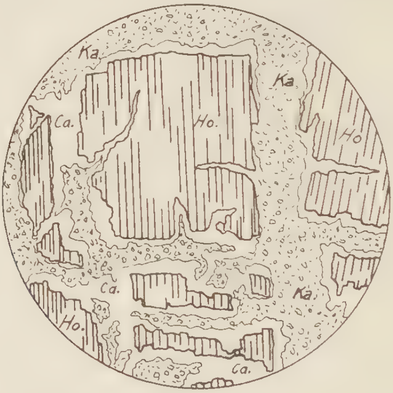

FIG. 6. Drawing of thin section×25. Hornblende (Ho) subjected to attack and filling by calcite (Ca) and later removal of portions of the calcite with the formation of kaolinite.

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[14] *Op. cit.*

Carbonate producing solutions evidently penetrated the rock at some time following its crystallization. Calcite filling "etched out" cavities in feldspar and hornblende is frequently observed in thin sections (Figs. 5 and 6). Crystals of calcite have also been found in openings in the rock along the walls of the tunnel. Possible sources of both calcium and magnesium carbonate may exist in adjacent unexposed areas of limestone. The complete history of the carbonate minerals is hidden. It does not appear, however, that these are a prerequisite to the later decay or weathering resulting in the formation of kaolinite.

KAOLINITE

The clay mineral is typical white kaolinite. It is soft, porous, adheres to the tongue, and goes to pieces when immersed in water.

It is for the most part finely crystalline, and a portion of a sample agitated in water and allowed to stand, will remain in suspension for several days. The largest amount of the clay, however, will settle in a few hours. All of the suspended particles settle rapidly, however, when a small amount of sodium hydroxide is added to the mixture. The small amount of sodium hydroxide added, apparently produces no material change in the nature of the clay, for *x*-ray diffraction patterns of the clay taken before and after such treatment, are identical.

The clay can be easily purified by agitation with water, settling, decanting, and filtering off the clay material remaining in suspension after the impurities have settled. Samples were purified in this way for chemical analysis and judging from the resultant analysis, all but 2.47% of the mineral impurities were removed from the clay.

The analysis by Mr. A. M. Smoot of Ledoux and Co., New York, is as follows:

	Per cent
SiO_2	54.73
Al_2O_3	38.37
TiO_2	1.35
Fe_2O_3	.40
CaO	.56
SO_3	.16
$H_2O+110°$	13.19
$H_2O-110°$	.50
Total	100.26

Alkalies, magnesium and zirconium were absent.

The ratio of $Al_2O_3:SiO_2$ according to the above analysis is 1:2·02 and the formula of the clay mineral would be: $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$. Titanium oxide, ferric oxide, calcium oxide, and sulphur trioxide are probably due to the impurities not separated out during purification.

The samples of the clay examined were so finely crystalline that only a partial optical examination was possible. The indices of refraction were found to vary between the limits $N\alpha = 1.556$ ($\pm .002$) and $N\gamma = 1.564$ ($\pm .002$), with a corresponding double refraction of 0.006. The optical character is (—) and the acute bisectrix is nearly perpendicular to the perfect cleavage. The flakes show a very small angle of extinction.

The x-ray diffraction pattern has the same intensity variation, and computations show the same interplanar spacing as patterns of anauxite from Bilin, Bohemia, and from the Ione formation of California. The measurements and the results of the computations of interplanar spacings for the Brooklyn clay, agree within the limits of experimental error with the anauxite-kaolinite figures given by Ross and Kerr.[15]

VERMICULITE

Greenish mica, probably vermiculite, is prominent in the weathered zone. In general it is produced by the decay of the biotite in the granodiorite. In places, however, it may be observed undergoing alteration to kaolinite. It is variable in optical properties. Selected flakes yielded the following optical data:

$N_\alpha = 1.585$, $N_\gamma = 1.593$ (approximately).
Double refraction, 0.008.
Wavy extinction, parallel in sections, normal to cleavage.
Pleochoric, X = green, Y = colorless, Z = pale yellow.
Biaxial (small angle).
Optically negative.

Chunks of flakes exfoliate upon heating with a blowpipe and the x-ray diffraction patterns closely resemble x-ray patterns of vermiculite, from Delaware Co., Pennsylvania, and do not agree with chlorite patterns taken in connection with previous investigations.

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[15] *Op. cit.* Also Ross, Clarence S., and Kerr, Paul F., The minerals of kaolin: *Jour. Amer. Ceram. Soc.*, (In press).

KAOLINIZATION

The feldspars are the first to undergo attack and replacement by kaolinite. An illustration of the attack upon a crystal of orthoclase is shown in Figure 7.

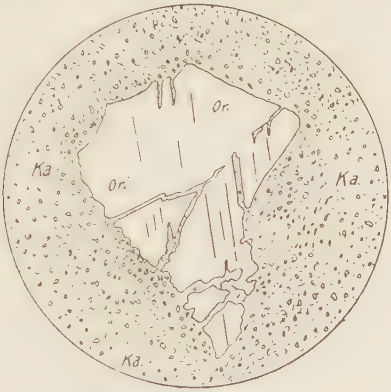

FIG. 7. Drawing of thin section×25. Orthoclase (Or) surrounded and in part replaced by kaolinite (Ka). Typical of the kaolinization of feldspar noted in thin sections.

The orthoclase section represents a single crystal as shown by simultaneous extinction throughout, yet it has been penetrated and cut in all directions with the resultant formation of kaolinite.

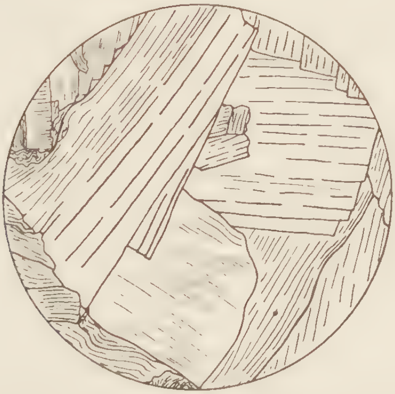

FIG. 8. Drawing of thin section × 25. A mass of green vermiculite which, judging from color variations in adjacent areas, is an alteration of biotite.

Hornblende is shown in Figure 6 to be undergoing replacement by kaolinite. In this instance, however, intermediate replacement of hornblende by calcite is in evidence.

A change from biotite to kaolinite appears to take place in stages. Fig. 8 represents what may be considered the first stage and at the same time one of the most common throughout the rock. The biotite is altered to vermiculite without change in form. The vermiculite is prominent particularly in the weathered zone, and in instances, almost pure green masses are to be found. The vermiculite is so prominent that it might be considered to represent a different process of mineralization if it were not for numerous isolated occurrences in which nearly all gradational phases from biotite through vermiculite to kaolinite are to be seen. Fig. 9 illustrates a portion of this evidence. Sheaf-like structures retain in part the original micaceous structure common to the biotite in the rock, yet are swollen on the margins. The margins are also largely kaolinite while the centers of the structures retain altered residual portions of the original mica.

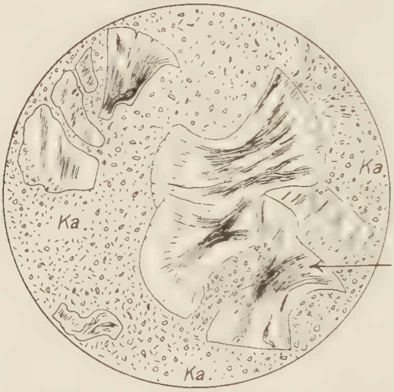

Fig. 9. Drawing of thin section × 25. Remnant structures originally biotite but now kaolinite within a ground mass of kaolinite. The sheaf-like structure is apparently due to the marginal expansion of the mica flakes, during the replacement. The streaks are dark colored residual stains. (Indicated by the arrow.)

Fig. 10 illustrates another way in which the replacement of biotite by kaolinite appears to take place. The mineral with well-defined cleavage shown in high relief is biotite. In parts of the figure it is still unaltered. In the center of the figure, appears a rope-like structure drawn to represent a gel-mineral (apparently amorphous). The gel-mineral is in places deep yellowish-brown in color, as if containing limonitic stain. Other portions, however are deep green and these in turn grade into extremely finely crystallized kaolinite. It would appear from this sequence from biotite to kaolinite through the gel-minerals, that the iron and extra elements from the biotite are lost during the gel stage. A predominance of green color after the first stage in gel formation suggests that perhaps the iron present has been reduced and that the chemical reactions bringing the alterations about may be reducing in character. Humphreys and Julien carried on no microscopic work but from their field observations, concluded that the rock decay was probably due to the corrosive action of organic acids acting in old peat-bogs. The character of the alterations observed in thin sections in no way refutes this hypothesis. In fact the production of a gel-like mineral and the subsequent crystalliza-

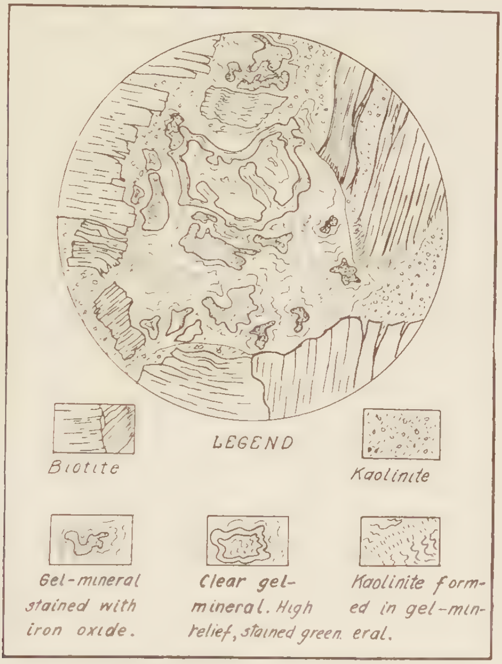
LEGEND
Biotite
Kaolinite
Gel-mineral stained with iron oxide.
Clear gel-mineral. High relief, stained green.
Kaolinite formed in gel-mineral.

FIG. 10. Drawing of thin section × 25. Progressive alteration in micaceous portion of the rock to form kaolinite. An isotropic brown gel-mineral is first produced which grades into a green gel-mineral phase. The latter grades in turn into a pale green gel-mineral which grades into kaolinite. The progressive loss of color and structure in the sequence of gel-minerals suggests reduction and removal of iron.

tion with removal of ferro-magnesian content might easily be brought about by the action of such acids.

The gel-minerals could not be isolated for identification but from the chemical nature of the end product allophane and halloysite may be judged to be present.

SUMMARY

A white clay discovered in a subway tunnel excavation near Newtown Creek, Long Island, is found to be kaolinite. It occurs beneath glacial till, as a weathering product of the Ravenswood granodiorite. It is associated with greenish less altered areas of weathered granodiorite containing vermiculite. The decay of the rock and the later formation of kaolinite were probably both produced by pre-glacial weathering.

The occurrence provides a description of a typical residual kaolin composed essentially of the mineral kaolinite as strictly defined. Emphasis is placed upon the necessity of careful identification in the case of kaolinite in order to distinguish the mineral from closely related species.

RAPID SPECIFIC GRAVITY DETERMINATIONS WITH CLERICI'S SOLUTION

Kenneth K. Landes, *University of Kansas.*

It has long been customary in certain mineralogical laboratories to use as an aid in the identification of nonmetallic minerals a series of test tubes containing liquids of various specific gravities. L. J. Spencer[1] has recently described an apparatus used in his laboratory consisting of eight test tubes of methylene iodide with a range from 2.12 to 3.32. Clear crystal mineral fragments are used as indicators and the specific gravity of the liquid is varied by adding or evaporating benzine until it matches that of the unknown mineral. The writer, inspired by Spencer's paper, has made up a set of heavy liquids and has derived considerable satisfaction from their use for a period of a year. However, Clerici's solution (thallium formate-malonate) was substituted for methylene iodide and a somewhat different procedure followed.

A frame was constructed composed of a base 2 by 6 in. with a length of 37 inches. Centered above this, with 5½ inches open space between, is a 2 by 4 of equal length. It is held in position by uprights at the end of the frame. Twenty-eight holes with a one-inch diameter have been bored through the 2 by 4 and to a shallow depth in the base. In order to conserve space these holes are staggered. Test tubes 8 inches long and one inch in external diameter occupy the holes. About 15cc. of heavy liquid fills the lower part of each test tube. This allows about 1¼ inches of the liquid to stand in the readily visible portion of the tube immediately above the base. The liquid in the first tube (at the left end of the rack) has a specific gravity of 2.0 and the gravities in the succeeding tubes increase in steps of 0.1 up to 4.1. This leaves six holes at the right end of the frame which may be used by tubes containing reserve liquid and washing water. A picture of the frame containing the heavy liquid set is shown.

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[1] Specific Gravities of Minerals, an index of some recent determinations: *Mineralogical Magazine*, Vol. **21**, No. 119, Dec. 1927, pp. 337–338.

Clerici's solution[2] has a double advantage over other heavy liquids in its complete miscibility with water and in its unusually high specific gravity. The maximum specific gravity obtainable from this solution lies between 4.2 and 4.3 at normal room temperatures. To secure liquids of lower specific gravity than the concentrated solution it is only necessary to mix with water. To increase the specific gravity of dilute Clerici solutions the steam bath is used. The test tubes in the set must be kept tightly stoppered or evaporation of the water will raise the specific gravity.

Any specific gravity at the lower end of the series may be obtained down to that of water, but the small number of minerals between 2.0 and 1.0 does not seem to justify extending the set in that direction. Nearly three-fourths of the 2,277 specific gravities listed by Spencer[3] fall between 2.0 and 4.0. In making up the liquids a Westphal balance was used and water added until the specific gravity came to within less than 0.01 of the desired point. For specific gravities of 3.0 and above a special balance with an extra heavy plummet had to be secured.[4] The variation between the original specific gravity and that obtained in a recheck a year later in no test tube exceeded 0.01. A black cloth is thrown over the frame when the liquids are not being used.

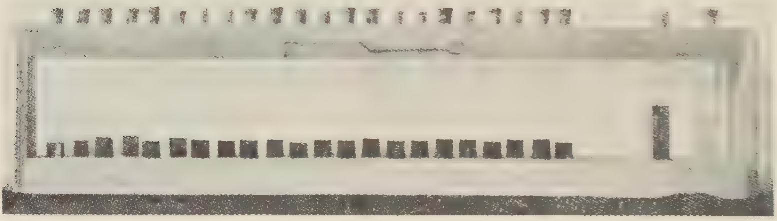

FIG. 1. Picture of specific gravity set.

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[2] E. Clerici, Preparazione di liquidi per la separazione dei minerali: *Atti. R. A. Lincei*, Rome, **16**, 187–195 (1907).

Helen E. Vassar, Clerici solution for mineral separation by gravity: *Am. Mineral.*, **10**, 123–125 (1925).

John D. Sullivan, Heavy liquids for mineralogical analyses: *U. S. B. M., Tech. Paper* **381**, (1927).

R. G. O'Meara and J. B. Clemmer, *U. S. B. M., Serial No.* **2897** (1928).

[3] *op. cit.*

[4] Purchased through a grant from the Graduate Research Fund, University of Kansas.

For ease in immersing the minerals in the liquid a very satisfactory mineral holder was devised. The perforated bowl of a section lifter was clipped from its handle and soldered onto the ring at the bottom of a deflagration spoon from which the cup had been removed. The rigid wire handle of the deflagrating spoon was shortened to a total length of 9½ inches and looped at the top for ease in lifting. The diameter of the perforated pan is about three-quarters of an inch which allows an easy movement up and down the tube, but prevents the mineral fragment from escaping over the side between spoon and tube wall and sinking to the bottom of the test tube. The perforations are small enough so that a mineral fragment of workable size will not pass through, but large enough to permit the liquid to move readily through the pan. When not in use the mineral holder hangs on short nails on the front of the rack as shown in the photograph.

To determine the specific gravity of a mineral a clean fragment is placed on the perforated pan and lowered to the bottom of one of the test tubes and its behavior observed. If it floats the holder can be pumped up and down in the tube so that the fragment is forced below the surface of the liquid and the speed at which it returns to the surface noted. If the return is very sluggish the mineral is evidently very close in specific gravity to that of the liquid. If the mineral is heavier than the liquid the same pumping motion is used and the speed at which the mineral sinks observed. After these observations have been made the mineral is removed with the holder from the tube, the whole immersed in a test tube filled with water in order to clean off the adhering liquid, and then the mineral fragment and the moist portion of the holder dried with a towel. This is to prevent dilution of the liquid next used. The same process is repeated in other tubes until two adjacent liquids are found in one of which the mineral floats and in the other sinks. This definitely places the specific within 0.1. Then an estimate is made into the second place as judged by the degree of sluggishness with which the mineral rises in one and falls in the other. After a very small amount of experience this can easily be determined to within 0.03, which is closer than the range of most minerals. The length of time necessary to make a specific gravity determination depends, of course, upon the number of tubes that it is necessary to use. The process of immersing, washing and drying does not take over 30 seconds to the tube.

An apparatus of this sort is of very little use unless there are readily accessible tables. In the appendix of Miers's Mineralogy the minerals are placed in the order of increasing mean specific gravities. Dana's Textbook of Mineralogy contains a table of minerals commonly crystalline, in which the primary classification is by crystal system and luster (metallic or nonmetallic). Within these groups the minerals are arranged in order of specific gravities with both the minimum and maximum gravities recorded. Spencer[5] has listed in order most of the minerals for which specific gravities were published in the years 1910 to 1927. As there are about 715 mineral species included in this list and 2,277 specific gravities, it is apparent that the names of some minerals will appear at a number of places in the list. A second table gives the minerals in alphabetical order with their minimum and maximum specific gravities. For use in the laboratory in combination with the specific gravity set just described, the writer has in preparation a graphic chart which will show for any determined specific gravity all the common minerals with a range including this point.

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[5] *op cit.*

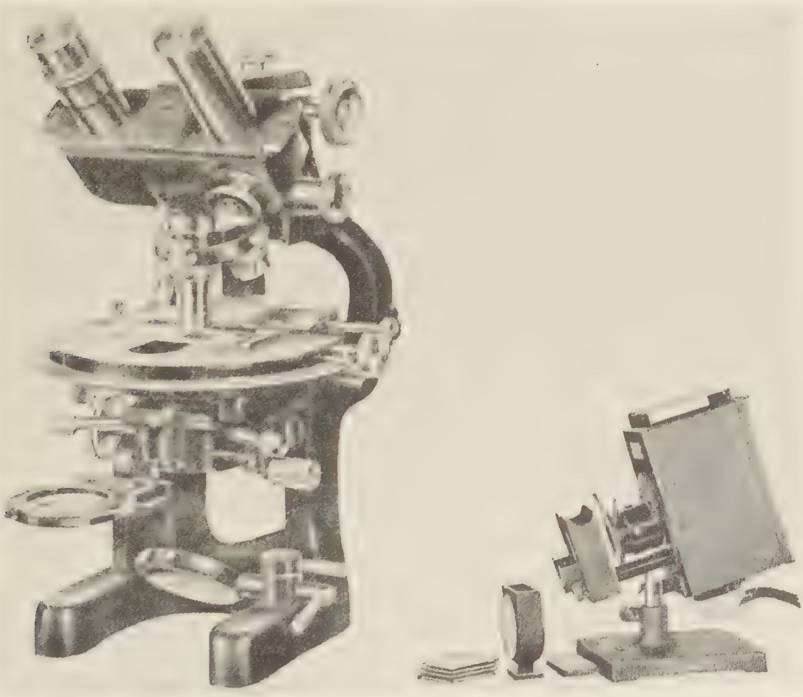
NOTES AND NEWS

THE DDE—A NEW RESEARCH BINOCULAR MICROSCOPE

R. W. Abell, *Bausch and Lomb Optical Co.*

A notable contribution to aid the work of the research scientist is the newly designed DDE research microscope, which marks a radical departure from any former type of research and photomicrographic microscope. The outstanding differences in construction from previous types are instantly noted from the illustration.

Most noticeable of these new ideas in design is the inclined position of the binocular eyepiece which allows the user to sit at the instrument in a natural upright and comfortable position. This is an especially commendable feature for continual observation over protracted periods.



The stand of the DDE Microscope also represents an innovation in design, the stage being directly in front of the operator. This "turned about" position offers much greater convenience of manipulation of objects on the stage and of the substage parts.

This new research microscope has been developed by the Bausch & Lomb Engineering Bureau from suggestions first offered by Dr. Lester W. Sharp of Cornell

University, with later helpful criticisms submitted by Dr. L. F. Randolph of the U. S. Department of Agriculture and Cornell University.

DESIGNED FOR PHOTOMICROGRAPHIC WORK

Since the advent of the binocular body, with its necessary prisms and mechanisms, there has been considerable weight placed upon the delicate fine adjustment mechanism. This weight has been too great to secure the responsive action necessary when working at high magnifications. However, the design of the DDE relieves the adjustment of this extra weight. This will be of special value in photomicrographic work where it is necessary to make long exposures.

The instrument may be equipped with either the regular single objective binocular body tubes for visual use and also for drawing with the camera lucida, or with the single tube for photomicrographic work.

For photomicrographic work the microscope is placed in a horizontal position, resting upon three points of support provided on the two arms and base. This leaves each part intact and the stage vertical.

UNUSUAL FEATURES IN MECHANICAL STAGE AND SUBSTAGE

The mechanical stage has many points which make for unusual facility in research work. It has forward and back adjustment by rack and pinion and transverse adjustment by multiple screw. These adjustments are operated from the right-hand side of the stage and the stage may be completely rotated with the objective in focus without interference. The specimen may be firmly fixed in position—a very desirable feature in photomicrographic work.

The substage is of the usual form, but combines many excellent features for fine focusing of condensers, dark ground illuminators, etc. A novel feature of the substage is a supplementary condenser on a swing arm. The focus of this condenser is so selected that the field of a 16 or 32 millimeter objective may be entirely filled with light without moving the substage or any of its elements from the usual position for high power objectives. Both high and low powers will function properly without readjustment of the substage condenser.

NEW RESEARCH LAMP DESIGNED

The development of the DDE Microscope made it advisable to design a new type of lamp, one particularly adapted to research microscope work. As a result, the No. 1815 Research Lamp has been produced by B. & L. as a fitting complement to the new DDE Microscope.

This new lamp meets two requirements which few designs satisfy; the one of utilizing the full aperture of the microscope condenser (up to N. A. 1.40) and the other of transmitting sufficient light to make possible critical illumination of the specimen under observation. Adjustments and focusing devices are conveniently placed, and the entire lamp is scientifically correct in every detail.

Professor-emeritus Jakob Beckenkamp of Würzburg, Germany, celebrated his 75th birthday on February 20. From 1897 to 1929 he was professor of mineralogy and crystallography at the University of Würzburg. At the present time he is continuing his investigations in the field of crystal structure.

Dr. Lea McIlvaine Luquer, tutor and associate professor of mineralogy at Columbia University from 1887 to 1925, died on January 30, at the age of sixty-four years.

The next meeting of the Geological and Mineralogical Societies will be held in Toronto, Ontario, December 29–31, 1930.

PROCEEDINGS OF SOCIETIES

PHILADELPHIA MINERALOGICAL SOCIETY

Academy of Natural Sciences, Philadelphia, Jan. 9, 1930.

A stated meeting of the Philadelphia Mineralogical Society was held on the above date, President Toothaker in the chair. Upon favorable recommendation of the Council, the following were elected as senior members: Messrs. H. E. McNelly, A. E. Mason and Norman Booker.

Dr. William F. Foshag, of the United States National Museum, addressed the Society on "*The Mineralogy of Some Ancient and Modern Saline Lakes.*" Introductory to his remarks on the various mineral localities in the Mojave Desert, Dr. Foshag described the various aspects of arid regions in general with particular emphasis on "playas," moist and dry, together with the minerals formed with varying conditions. Particular attention was called to Rhoads Marsh, Teels Marsh, Columbus Marsh and Fish Lake, Nevada, in which were found an abundance of thenardite, glauberite and "cotton-ball" ulexite; also reference was made to Searles Lake, California, which produces hanksite, blödite, gay-lussite, sulphohalite and quantities of octahedral halite. Among the Tertiary playas, were described the extensive borax deposits in San Bernardino County, California, especially those located at the junction of Furnace Creek and Death Valley, and the very extensive individual deposits of ulexite at Mount Blanco. Kramer, the type locality for proberite and kernite, the recently described borate minerals, was treated at some length.

Dr. Foshag related his various experiences collecting in these interesting localities and exhibited numerous attractive specimens which he obtained. His talk which was illustrated with many excellent lantern slides was very enthusiastically received.

Several members showed additional finds of attractive quartz crystals found by them at Bridgeport. The meeting adjourned with an attendance of 55.

LESTER W. STROCK, *Secretary*

MINERALOGICAL SOCIETY OF GREAT BRITAIN AND IRELAND

MINERALOGICAL SOCIETY, January 14. Dr. G. T. Prior in the chair.

The following papers were read by DR. L. J. SPENCER: SIR DOUGLAS MAWSON: *On the occurrence of potassium nitrate near Goyder's Pass, McDonnell Ranges, Central Australia.* The nitre occurs as encrustations on the walls and impregnations in the wall-rock in small caves in dolomitic limestone. The roof of the caves consists of a case-hardened crust formed by superficial silicification and ferruginization of the limestone; and it is this impervious crust that has enabled the nitrates, probably of animal origin, to be preserved. Mention is made of some other occurrences of mineral nitrates in Australia. DR. LOUIS T. NEL: *A new occurrence of zunyite near*

Postmasburg, South Africa. The mineral zunyite, previously known only from Colorado, has been found in some abundance in altered, highly aluminous shales and flagstones in the vicinity of the deposits of manganese ore of the Postmasburg District in Cape Province. Minute perfectly developed tetrahedra are aggregated in clusters or are disseminated through the rock, which contains also diaspore kaolin, and leverrierite. Most of the tetrahedra are simple, but a few are interpenetration twins with a triad axis as twin-axis. Analyses agree with the formula $Al_8(OH,F,Cl)_{12}(SiO_4)_3$.

Mr. F. N. Ashcroft exhibited minerals from Broken Hill, Rhodesia and from other localities, and Mr. W. Campbell Smith exhibited specimens and photomicrographs of volcanic rocks from Kenya Colony.

W. Campbell Smith, *General Secretary.*

BOOK REVIEWS

ELEMENTS OF MINERALOGY. PART III. DETERMINATIVE TABLES.

With colored chart and two diagrams in pocket on cover. Entirely rewritten and enlarged. Alexander N. Winchell. Second edition. XII+204 pages. John Wiley & Sons, Inc., *New York.* **1929**. Price $4.50.

This is the third part, or volume, of a series pertaining to *Elements of Mineralogy.* Part I deals with principles and methods; Part II contains descriptions of minerals with special reference to their optic and microscopic characters; and Part III summarizes the data recorded in Part II with minor additions so as to include new data that have appeared since Part II was published.

Five determinative tables comprise Part III. Table 1 deals with the common minerals that are opaque in thin sections. Minerals which are subtranslucent to opaque are inserted in more than one table. Table II is based on birefringence primarily, with refringence as a contributing factor in determining 56 smaller groups of minerals. These groups are limited by the following values of N: $N<1.48$; $N>1.48<1.54$; $N>1.53<1.59$; $N>1.59<1.66$; $N>1.66<1.74$; $N>1.74<2.00$; $N>2.00$. If a mineral has a lower index than balsam its relief may be characterized as negative, if higher, positive.

Color and pleochroism form the basis of the classification of the minerals into 26 subdivisions in Table III. While the first three tables are intended for identification of minerals in thin sections, the fourth and fifth tables are designed essentially for use with powders and immersion liquids.

Tables 4 and 5 are based upon refringence and dispersion, respectively. The dispersion indicated is the difference between the index in light of 4861 Å wave length (=F, the Frauenhofer line or the β line of hydrogen), and the index in light of 6563 Å wave length (=C, the Frauenhofer line or the α line of hydrogen). In the tables this difference is expressed as F-C. Three useful charts accompany the tables, and four different styles of type are used to distinguish between the very common, common, less common and rare minerals.

The author is to be congratulated in completing this series of three books on the Elements of Optical Mineralogy. As the minerals listed and described are not confined to the rock-forming types but include practically all non-opaque minerals whose optical properties are known, the tables should prove extremely useful to all who employ the polarizing microscope and optical methods for purposes of mineral identification.

W. F. H.

ASBESTOS. A LIST OF REFERENCES TO MATERIAL IN THE NEW YORK PUBLIC LIBRARY. Compiled by William B. Gamble. The New York Public Library, **1929**. Price 50 cents.

In this pamphlet the author brings together all titles of abstracts relating to asbestos that are to be found in the New York Public Library. The list contains 1075 titles and represents all references in the Library on September 1, 1929. In most instances a brief statement is added indicating the nature of the article. Likewise 519 entries are appended dealing with patents granted in the United States, Great Britain, Germany and Canada. The task of compiling and arranging the 1594 references has been very well done and the book should be of great assistance to those interested in asbestos and its uses.

W. F. H.

KRISTALLZEICHNEN. ROBERT L. PARKER. VI+112 pages, 35 text figures, and 50 drawing sheets in portfolio. Borntraeger, *Berlin*, **1929**. Price 20 Marks.

This is one of the few books devoted entirely to the subject of crystal drawing. There are two others known to the reviewer: HINTS ON CRYSTAL DRAWING by Margaret Reeks, *London*, **1908**, and KRISTÁLYSZERKESZTES by L. Tokody, *Budapest*, **1925** (in Hungarian), but neither of these are mentioned in the bibliography.

The book consists of two parts; the first deals with the theory and practice of crystal drawing and the second includes a series of tables to aid in crystal drawing.

After a general discussion of various orthographic and clinographic projections, the following methods of crystal drawing are described: (1) the method of intersection edges on an axial cross, (2) the method of coordinates of direction points of intersections on an axial cross (this method was described by C. B. Slawson in the *American Mineralogist*, vol. **6**. pp. 155–158, 1921), (3) the method of the stereographic projection (no reference is made, either in the bibliography or in the text, to the original article on this method by F. Stöber, *Bull. fran. Soc. Min.*, vol. **22**, pp. 42–60, 1899), and (4) the method of the gnomonic projection. Two other omissions in the bibliography may be noted: (1) "*Practical Crystal Drawing*" (based upon gnomonic projection) by Mary W. Porter, *American Mineralogist*, vol. **5**, pp. 89–95, 1920, and (2) "*The Addition and Subtraction Rule in Geometrical Crystallography*" (projections of intersection edges in orthographic projections are obtained by subtracting Miller indices, index by index) by Austin F. Rogers, *American Mineralogist*, vol. **11**, pp. 303–315, 1926.

In addition to the four methods of crystal drawing enumerated above, the author describes a new method in which use is made of "Bildkantenazimute" or directions of intersection edges. The directions of these edges or zone-axes are calculated in terms of azimuth angles from the zone-axis [001] taken as 0°. These angles for various zone-axes can be plotted on the accompanying sheets which give a hollow circle of 10 cm. radius divided into half degrees. The partial radii are printed in blue so that they will not show when the drawings are photographed for reproduction.

The second part of the book consists of a series of tables used principally to determine azimuth angles of various intersection edges (in terms of zone-indices) for isometric crystals and twenty of the more common non-isometric minerals. It seems likely that these tables and the accompanying drawing sheets may be useful if any considerable number of crystals of a given mineral have to be drawn, for axial cross, stereographic projection, and gnomonic projection may all be dispensed with.

While the book falls somewhat short of being a complete treatise on crystal drawing, it will doubtless be found useful to any who are especially interested in the subject.

A. F. R.

MINERALOGY. Sir Henry A. Miers. Revised by H. L. Bowman. 2nd edition. XX plus 658 pages. Macmillan and Co., Ltd., *London*. Macmillan Company, *New York*. **1929**. Price, $8.50.

This well known standard textbook, the first edition of which was printed in 1902, has recently appeared in its second edition. Containing 658 pages and 761 illustrations, it is written in typical English style, explanations are complete and clear, and the subject matter is well classified and arranged.

Every phase of mineralogy is discussed at some length. An inclusive selection of mineral descriptions is found in the 260 pages devoted to descriptive mineralogy. This is followed by 32 pages of descriptive and determinative tables; the three principal ones, with subdivisions, making fourteen tables in all. The three principal tables contain a complete classified list of minerals, tables of chemical reactions and of physical properties. Separate tables under the last division include the arrangement of minerals according to index of refraction, birefringence, values of 2E and 2V, and specific gravity.

As a textbook this work is easily sufficient and well adapted to a thorough two-year course in pure mineralogy. A few minor criticisms might be made, such as the frequent use of X, Y, and Z in designating the crystallographic axes, in place of the usual *a*, *b*, and *c*; reference of many hexagonal crystals to rhombohedral axes; and a few antiquated illustrations. It must be said, however, that these certainly are not serious defects, if they may be so regarded at all.

While it may be too extensive a text for the usual introductory course in Mineralogy as given in most American universities, nevertheless, it will prove acceptable for some courses, and certainly will be found a valuable reference work in any field of mineralogic interest.

L. S. Brown

ANORGANISCHE UND ORGANISCHE ENTFÄRBUNGSMITTEL. Leopold Singer. Volume **XX** of *Technische Fortschrittsberichte*. VIII+251 pages. Published by Theodor Steinkopff, *Dresden*, **1929**. Price 21.50 R.M. bound.

This book deals with natural and artificial decolorizing agents, and contains a very complete bibliography of this extensive branch of technology. Fifteen pages of author's index at the end of the volume give one an idea of the number of references in this work.

The author makes no attempt to treat any part of the subject in detail, but simply describes in a few words the discoveries and applications of the various decolorizing agents. Only about the first 20 pages are of general interest. The rest of the volume enumerates the manufacture and uses of the agents. Patents are also given in this connection.

The theory of decolorization (adsorption) is treated on pages 29 to 37.

John W. Gruner.